CHARACTERIZATION OF MODAL DOMAIN FIBER OPTIC SENSORS FOR VIBRATION DETECTION and SUPPRESSION IN FLEXIBLE STRUCTURES

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Project Summary

The research supported under this Grant demonstrated experimentally for the first time the inclusion of a modal domain optical fiber sensor as a strain sensor in a control system designed to damp vibrations in a flexible beam. The experimental work included in the design and development of in–line fiber modal control devices and was supported by an analysis of the complete system. This analysis included the development of a model of the modal domain sensor for control system design and a thorough analysis of the performance of the system under a variety of operating conditions. The results of this research were completely documented in the following publications.

1. Overall description of the fiber sensor, beam, and control system is given in:

David E. Cox, "Active Control of Flexible Structures Using Fiber Optic Modal Domain Sensors," Master's Thesis, June, 1990.

D. E. Cox and D. K. Lindner, "Active Control for Vibration Suppression in a Flexible Beam Using a Modal Domain Optical Fiber Sensor," submitted to the ASME Journal of Vibration and Acoustics, 1990.

D. Cox, D. Thomas, K. Reichard, D. K. Lindner, and R. O. Claus, "Modal Domain Fiber Optic Sensor for Closed Loop Vibration Control of a Flexible Beam," Proc. of SPIE Conference on OE/Fibers, Vol. 1170, Boston, MA, Sept. 1989, pp. 372–383.

D. Cox, D. Thomas, K. Reichard, D. K. Lindner, and R. O. Claus, "Vibration Control of a Flexible Beam Using a Distributed Fiber Optic Sensor," Proc. of the 28th IEEE Conference on Decision and Control, Tampa, FL, December, 1989, pp. 2685–6.

D. E. Cox, D. K. Lindner, C. Z. Furness, and S. Bingulac, "Identification and Control of a Flexible Beam Using a Modal Domain Sensor," accepted for the SPIE Conference on OE/Fibers, San Jose, CA, 1990.

J. K. Shaw, A. M. Vengsarhar and R. O. Claus, "Theoretical Analysis of Two–Mode, Elliptical Core Fiber," Proc. SPIE O/E Fiber Laser (San Jose, CA), September 1990.

K. A. Murphy, M. S. Miller, A. M. Vengsarhar and R. O. Claus, "Elliptical–Core Two Mode, Optical–Fiber Sensor Implementation Methods," Jnl. Lightwave Tech., Nov. 1990.

C. Furness, S. Bingulac, D. K. Lindner, and R. O. Claus, "Parameter Identification of a Flexible Beam Using a Fiber Optic Sensor," to appear in the Proc. of the 2nd USAS/NASA Workshop on System Identification and Health Monitoring of Precision Space Structures, California Institute of Technology, Pasadena, CA, March, 1990.

2. A description of the control design methodology (developed for this project) is given in:

D. K. Lindner, T. Celano, and E. Ide, "Vibration Suppression Using a Proofmass Actuator Operating in Stroke/Force Saturation," submitted to ASME Journal of Vibration and Acoustics, 1990.

3. An analysis of the control system performance when the structure undergoes large deflections is given in:

D. K. Lindner, G. A. Zvonar, W. T. Baumann, and P. Delos, "Nonlinear Effects of a Modal Domain Optical Fiber Sensor in a Vibration Suppression Control Loop for a Flexible Structure," Internal Report, Fiber & Electro–Optics Research Center, Virginia Tech, Blacksburg, VA, 1990; also paper in preparation.

D. K. Lindner, P. Delos, and W. T. Baumann, "Nonlinear Effects of a Modal Domain Fiber Optic Sensor in a Vibration Suppression Control Loop for a Flexible Structure," Proc. of the IEEE Southeastcon, '90, New Orleans, LA, April, 1990, pp. 126–9.

P. Delos and D. K. Lindner, "Nonlinear Effects of Large Amplitude Displacements in Modal Domain Fiber Optic Sensors," Internal Report, Virginia Tech, Blacksburg, VA 1989.

4. Extensions of the results reported above and ideas currently under investigation are given in:

P. Delos and G. A. Zvonar, "Fringe Counting Device for Modal Domain Optical Fiber Sensors," Internal Report, Fiber & Electro–Optic Research Center, Virginia Tech, Blacksburg, VA, June, 1990.

D. K. Lindner, R. O. Claus, and H. Cudney, "Modal Domain Optical Fiber Sensors for Vibration Sensing in Large Flexible Truss Structures," accepted for the 4th Annual NASA/DOD Technology Conference, Orlando, FL, November 5–7, 1990.

D. K. Lindner, K. Reichard, W. T. Baumann, and M. F. Barsky, "Measurement and Control of Flexible Stuctures Using Distributed Sensors," accepted for the IEEE Conf. on Decision and Control, Honolulu, HI, 1990.

D. K. Lindner and R. O. Claus, "Vibration Sensing in Flexible Structures Using a Distributed–Effect Modal Domain Optical Fiber Sensor," submitted to the SPIE Conf. on Aerospace Sensing, Orlando, FL, April 1–5, 1991.

Student Support

In the previous year, David E. Cox was supported to the conclusion of his Master's Degree. (His thesis is listed above.) He subsequently took a position in the Spacecraft Control Branch at NASA Langley Research Center.

Also, Peter Delos and Gregory Zvonar were supported on undergraduate scholarships. Their contributions are also noted above. Peter was recommended by NASA–LaRC staff for this scholarship program.